

Ground reaction forces and gait parameters during motorized and non-motorized treadmill walking and running on the International Space Station treadmill

Jason Norcross<sup>1</sup>, John DeWitt<sup>2</sup>, Stuart M.C. Lee<sup>1</sup>, Frank McCleary<sup>1</sup>, W. Brent Edwards<sup>3</sup>, R. Donald Hagan<sup>4</sup>, FACSM. <sup>1</sup>*Wyle Life Sciences*, <sup>2</sup>*Bergaila Engineering Services*, <sup>3</sup>*LZ Technology* and <sup>4</sup>*NASA Johnson Space Center, Houston, TX*

Both motorized (T-M) and non-motorized (T-NM) treadmill locomotion are used on the International Space Station (ISS) as countermeasures to the deleterious effects of prolonged weightlessness. However, the ground reaction forces (GRF) and gait parameters of these exercise modes have not been examined.

**Purpose:** To determine if differences in GRF and gait parameters exist while walking ( $1.34 \text{ m}\cdot\text{s}^{-1}$ ) and running ( $3.13 \text{ m}\cdot\text{s}^{-1}$ ) on T-M and T-NM.

**Methods:** Twenty subjects (10 men, 10 women;  $31\pm5$  yr,  $172\pm10$  cm,  $68\pm13$  kg,  $\text{VO}_{2\text{pk}} 45.5\pm5.4 \text{ ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ , mean  $\pm$ SD) exercised on a ground-based version of the ISS treadmill. Subjects completed three 10-s trials at  $1.34$  and  $3.13 \text{ m}\cdot\text{s}^{-1}$  on either T-M or T-NM on separate days in a random order. To drive the treadmill belt during T-NM, subjects wore a harness attached to a support structure at the back of the treadmill so as to allow more natural locomotion; no harness was worn during T-M. GRF and gait parameters were measured with pressure insoles sampling at 120 Hz. These parameters included impulse (IMP), loading rate (LR), peak ground reaction force (pGRF), contact

time (CT), stride time (ST), and stride length (SL). Means were calculated from all three trials at each speed. Paired t-tests were used to assess differences between treadmill modes within each speed ( $p<0.05$ ).

**Results:** CT, ST, SL and IMP were significantly less during T-NM at both speeds. There were no significant differences between modes in pGRF at either speed. At  $3.13 \text{ m}\cdot\text{s}^{-1}$ , LR was significantly lower during T-NM, but was not different at  $1.34 \text{ m}\cdot\text{s}^{-1}$ .

| Mode | Speed (m/s) | ST (s)            | CT (s)            | SL (m)            | IMP (BW/s)     | LR (BW*ms)         | pGRF (BW)       |
|------|-------------|-------------------|-------------------|-------------------|----------------|--------------------|-----------------|
| T-M  | 1.34        | $1.00 \pm 0.05$   | $0.58 \pm 0.03$   | $1.54 \pm 0.07$   | $475 \pm 31$   | $9.98 \pm 2.45$    | $1.41 \pm 0.12$ |
| T-NM | 1.34        | $0.91 \pm 0.06^*$ | $0.54 \pm 0.04^*$ | $1.40 \pm 0.08^*$ | $432 \pm 33^*$ | $9.16 \pm 2.27$    | $1.43 \pm 0.13$ |
| T-M  | 3.13        | $0.69 \pm 0.04$   | $0.24 \pm 0.02$   | $2.46 \pm 0.13$   | $324 \pm 22$   | $39.32 \pm 11.95$  | $2.33 \pm 0.15$ |
| T-NM | 3.13        | $0.58 \pm 0.05^*$ | $0.22 \pm 0.02^*$ | $2.10 \pm 0.16^*$ | $270 \pm 31^*$ | $20.13 \pm 2.57^*$ | $2.26 \pm 0.28$ |

\*Results significantly different than T-M ( $p<0.05$ )

**Conclusion:** Dissimilar GRF and gait parameters suggest that T-M and T-NM locomotion may elicit different physiologic effects. T-NM may result in a reduced stimulus to bone formation due to a lower LR, but an increased energy cost as a result of shorter, more frequent strides. Therefore, the usage of each mode should depend upon the desired training stimulus.